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Anne Raudaskoski, Torben Lenau, Tapani Jokinen, Anna Velander Gisslén and Anna-Luise Metze

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Contents

Summary of key findings

80% of environmental pollution and 90% of manufacturing costs are the result of decisions made at the product design stage.[1] Presently most electrical/electronic equipment (EEE) is not designed for recycling, let alone for circulation. Plastics in these products account for about 20% of material use, and through better design, significant environmental and financial savings could be gained. For example, using recycled plastic in an electrical/electronic product could reduce the environmental impact of a single product by over 20%. If all waste electrical and electronic equipment (WEEE) plastics in Europe were recycled, estimated CO_2 emission reductions would be over 2.5 million metric tonnes per year.

Technological solutions and circular design opportunities already exist, but for various reasons they haven't been implemented yet. Some challenges, such as ease of disassembly, could be resolved through better communication and by sharing learnings across the value chain. In addition, customers increasingly expect companies to take the lead and offer them more sustainable choices.

Instead of creating WEEE, we should focus on developing CEEE: Circular Electrical and Electronic Equipment.

The ultimate goal should be designing and setting up a system that enables circulation – in other words, taking products back and reprocessing material back to the same product over and over again.

The purpose of this report is to drive the EEE sector towards a circular economy. The case examples collected for the report show how different stages of the lifecycle can be designed so that plastics circulation becomes possible and makes business sense. Now it is time to take a leap in material flow management and scale up these circular solutions across the industry.

List of recommendations

Circular Design Principles

Embedding a circular economy vision and approach into the company's strategy is a first step every company could and should take. Developing and implementing circular design principles is a concrete way to execute the strategy, and it also ensures that the company is future-fit in a changing and resource-scarce business environment.

[1] European Parliament: http://www.europarl.europa.eu/doceo/document/A-8-2018-0165_EN.html

Roundtable for plastics circulation

Circular design can and should play an important role at each stage of the lifecycle. A roundtable – a high-level platform bringing together companies and value chain actors to create sector-wide Circular Design Principles – is crucial in order to capture economic value that is currently lost due to linear design. Taking a broader view; a great many current challenges and linear practices could be addressed through a closer value chain collaboration. Brands could learn from recyclers and take these learnings into their circular design processes and vice versa; recyclers could tailor their offerings based on the specific needs of each customer.

In addition, there are currently a number of different ways of handling and recycling plastics; there is a need to set up bigger clusters for side stream management to drive up volumes and economic viability.

Various networks exist, such as WEEE Forum[2] and Next Wave[3] and many others, that could join forces and take the lead on this. Producer responsibility organisations in the EU member states could also be catalysts of change; for example, ESR[4] has created an ecosystem around the WEEE industry to develop more efficient and effective collection and treatment systems in France.

Material identification and circular material choices

A prerequisite for the highest possible value capture is material identification. Incorrect markings on plastics have resulted in a situation whereby recyclers don't trust the markings and therefore different types of plastics are not separated even if it were technologically possible.

Coupled with the issue of identification is the opportunity to harmonise plastics use. Going through different polymer types used in production and shifting to the most commonly used polymers is an effective way to contribute to recycling. However, this inventory should be done in collaboration with the sector, as it has a direct impact on recyclers. If recyclers knew what polymer types were coming in, they could make necessary investments in novel technologies, thus resulting in a more consistent quality of material. Furthermore, designing out chemicals and additives improves circulation opportunities significantly.

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[2] http://www.weee-forum.org/
[3] https://www.nextwaveplastics.org/
[4] https://www.eco-systemes.fr/en/all-about-eco-systemes

Legislation

A requirement for using recycled content would speed up the market transition towards circularity. In addition, requirements for circular design principles, especially reparability, modularity, upgradability, and ease of disassembly could be first encouraged in the form of sector-wide principles and gradually formulated into requirements. Removing existing barriers, such as transporting e-waste across borders within the EU, is equally important. Nordic countries are well positioned to build a Nordic Cluster of harmonisation for a take-back recycling system to support scalability.

Embedding environmental calculations into the decision-making process

To operate within planetary boundaries it is necessary to ensure that products are designed, manufactured and circulated in such a way as truly takes us closer to a circular economy. Calculating avoided environmental costs provides a good business case and foundation for decision-making when starting a circular journey.

Glossary

WEEE	Waste Electrical and Electronic Equipment.
EEE	Electrical and Electronic Equipment.
CEEE	Circular Electrical and Electronic Equipment.
PCR	Post Consumer Recycled Plastics.

1. Introduction – what is the challenge?

1.1 Context

Design is the key to move towards a circular economy from the linear take-make-waste economic model; 80% of environmental pollution and 90% of manufacturing costs are the result of decisions made at the product design stage.[5] Presently most electrical/electronic products (EEE) are not designed for recycling, let alone for circulation. Plastics in these products account for about 20% of material use, and through better design could generate huge environmental and financial savings.

Globally the amount of e-waste is projected to grow rapidly; by 2021 there will be 52 million tonnes of e-waste (including PCs, laptops, smartphones, tablets and monitors *but* excluding a wide range of other electrical equipment such as refrigerators, lighting, measuring devices, etc.). By 2040 carbon emissions and emissions from use of the above electronics will reach 14% of total global emissions.[6] It is estimated that globally all plastic production and plastic waste incineration will generate 400 million tonnes of CO_2 emissions.

The annual plastic demand in Europe is 52 million tonnes, of which plastics used in electrical and electronic products count for 6.2%. Combined with the automotive industry, these two sectors use nearly 16.3% of plastics, which equals 8.5 million tonnes per year.[7] The quantity of plastic waste from EEE sources in the EU is around 1.2 million tonnes per year.[8] According to estimates, reuse of PCR plastics in EEE is estimated below 1% (RDC Environment 2017).[9]

Using recycled plastic in an electrical/electronic product could reduce the environmental impact of a single product by over 20%.[10] Instead of WEEE (Waste Electrical and Electronic Equipment), we should focus on developing CEEE: Circular Electrical and Electronic Equipment.

Technological solutions and circular design opportunities already exist, but for various reasons they haven't been implemented yet. Some challenges, such as ease of disassembly, could be resolved through better communication and sharing learnings across the value chain.

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[5] European Parliament: http://www.europarl.europa.eu/doceo/document/A-8-2018-0165_EN.html
[6] *A New Circular Vision for Electronics - Time for a Global Reboot* (2019).
[7] *Plastics - the facts 2018, Plastics Europe*
https://www.plasticseurope.org/application/files/6315/4510/9658/Plastics_the_facts_2018_AF_web.pdf
[8] European Electronics Recyclers Association Position Paper*: Weee Plastics Recycling Strategy Proposals* (2017).
[9] CLOSEWEEE project: *Report on proposed Ecodesign Policy Concept and recommendation to strengthen Design for Recycling and the usage of post-consumer recycled plastics in new products* (2018).
[10] Nordic Council of Ministers: *Nordic plastic value chains - Case WEEE (Waste Electrical and Electronic Equipment)* (2015).

This report focuses on circularity for plastics in electrical and electronic equipment (CEEE). Due to the rising number and importance of electric vehicles in tackling climate change, one car-maker brand was included in the research.

The following pages focus particularly on the crucial role of design. How can design further the sustainable use of plastic and the transition towards a circular economy? Which key factors from the design point of view enable the circulation of plastics and what hinders closing the loop?

The report introduces the concept of circular design and takes a step beyond Design for Recycling (DFR), which was called for in the previous Nordic Council of Ministers reports[11] as a way to improve plastics recycling and reduce the environmental impact. The ultimate goal should be designing and setting up a system that enables circulation – in other words, taking products back and reprocessing material back to the same product over and over again.

The text builds on the Nordic Programme to Reduce the Environmental impact of Plastics[12] and the EU Strategy for Plastics in a Circular Economy, which presents that in the future "design and production of plastics and plastic products fully respect reuse, repair and recycling".[13]

A number of leading brands, plastic recyclers, and experts were interviewed for this report. Their case examples show that there is huge business potential in improving plastics circulation. Customers increasingly expect companies to take the lead and offer them more sustainable choices. Moreover, these brands show that necessary changes in design principles and manufacturing processes can and should be made to keep the existing plastics in use as long as possible. Now it is time to take a leap in material flow management and scale up these circular solutions across the industry.

We would like to thank all the interviewees as well as CEO Pascal Leroy of WEEE Forum and PolyCE Project Coordinator Gergana Dimitrova of Fraunhofer Institute for Reliability and Microintegration IZM for reviewing the text.

1.2 Methodology

1.2.1 Key research questions

The purpose of the report is to drive the EEE sector towards a circular economy. The case examples collected for the report show how different stages of the lifecycle can be designed so that plastics circulation becomes possible. The key research questions were:

[11] *Plastic Waste Markets: Overcoming barriers to better resource utilisation* (2018); *Nordic plastic value chains - Case WEEE (Waste Electrical and Electronic Equipment)* (2015).
[12] *Nordic Programme to Reduce the Environmental impact of Plastics* (2017).
[13] *European Strategy for Plastics in a Circular Economy* (2018).

- What are the organisation's design principles and how are they implemented?
- In what ways do design approaches and practices aim for sustainable circularity?
- How have reparability, upgradability, modularity and ease of disassembly of the product been addressed?
- What is the policy on chemicals and hazardous substances?
- What is the end-of-life strategy?
- Does the business model support the goal of decoupling growth from the use of virgin raw materials and natural resources?

1.2.2 Methodology

The methodology applied in this report was interviews with selected key players in the market for electronic and plastic products, which includes producing companies, retailers, recyclers, authorities, etc. In total 23 organisations (see Table 1) were interviewed. At first, companies within the Nordic countries were considered, but it quickly became apparent that, in particular, larger companies are multinational, and the selection criteria was then broadened to include other countries including Philips in the Netherlands, Dell Computer in Ireland, and Fujitsu in Japan.

An interview guide was made consisting of the following headlines:

- Basic information and practicalities
- Product information
- 1. theme: sustainability (company level)
- 2. theme: end-of-life (reuse, remanufacturing, recycling) product level
- 3. theme: designing upgradability, modularity, repair
- 4. theme: chemicals/hazardous substances/health and safety
- 5. theme: benefits of plastics and novel ways of using them
- 6. theme: business model and partnerships.

Most of the interviews were conducted over the phone, recorded and sent to the interviewee for approval. Interviews were made between January and April 2019.

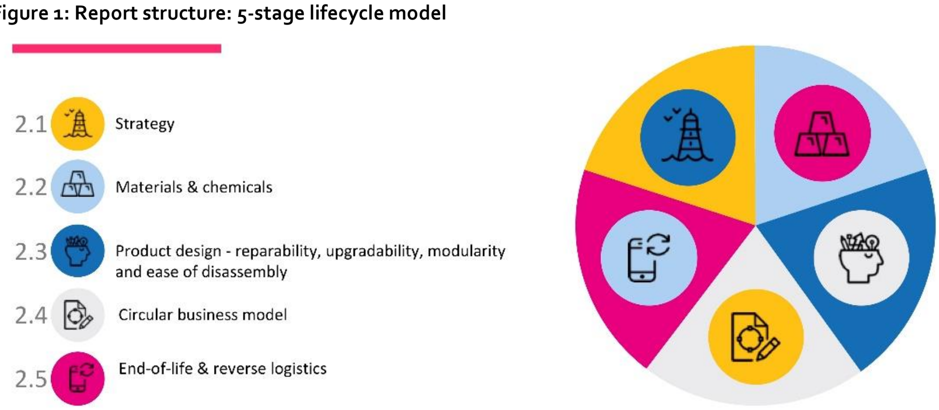
Table 1: Overview of interviewed companies

Organisation	Area	BtB/BtC
Fujitsu	ICT software and services and IT equipment	BtB/BtC
Oticon	Hearing aids	BtC
Zen Robotics	AI-based recycling technology	BtB
Dell	ICT solutions and IT equipment	BtB/BtC
Philips	Health care products, consumer electronics	BtB
Energy Authority	Legislation	BtB/BtC
Finnish Plastics Industries Federation	Plastics industry membership organisation	B2B
Ensto	Electrical solutions	BtB
Fortum	Recycler	BtB
Kuusakoski	Recycler	BtB
Plastix	Plastic recycler	BtB
Plastkretsen	Plastic recycler	BtB
Sustonable	Kitchen and bathroom panels	BtB
Volvo	Transport	BtB/BtC
Novo Nordisk	Medical products	BtC
Ohmatex	Electronic textiles	BtB
Inrego	Refurbished consumer electronics	BtC
Fischer Lighting	LED lighting	BtB
BODY BIKE International	Fitness bikes	BtB
B&O	Consumer electronics	BtC
Electrolux	Consumer electronics	BtC
MatKon	Consumer electronics	BtC
Neste	Recycler	BtB

Research questions were designed according to a lifecycle model consisting of eight stages: 1) design 2) materials 3) manufacturing 4) product 5) logistics 6) business model and marketing 7) use 8) after use.

The lifecycle model was then modified to serve the report structure better and resulted in a five-stage model: 1) strategy 2) materials and chemicals 3) product design: reparability, upgradability, modularity and ease of disassembly 4) circular business models 5) end-of-life and reverse logistics.

Figure 1: Report structure: 5-stage lifecycle model



2. Embedding Circular Design Across the Lifecycle

"It's more than just environmental strategy – it's good business." – Dell.

This chapter explains five stages of the lifecycle in detail and with a number of different case studies. The five stages are: 1) strategy 2) materials and chemicals 3) product design: reparability, upgradability, modularity and ease of disassembly 4) circular business model 5) end-of-life and reverse logistics.

2.1 Lifecycle stage: Circular economy as a strategy

Many forerunner companies have already embedded circular economy into their strategies. This is reflected directly in the company's R&D, as the whole approach and many internal processes need to change when transitioning from a linear take-make-waste to a circular way of thinking, operating and doing business. Circular economy can be defined as *a restorative and regenerative industrial system, where waste and emissions are designed out through slowing, closing, and narrowing material and energy loops.*[14]

Traditionally, design based on linear-economy thinking mainly focuses on the *manufacturing* and *use phase* through, for example, optimal material choices, energy efficiency, functionality and aesthetics, and it is based on the linear business model of "selling more and selling faster".

In this report we use the term "circular design"[15] to describe the whole internal process consisting of 1) R&D 2) design 3) business model development. Circular design plays a key role in a systemic transition towards a circular economy. No matter what lifecycle stage is in question, the change starts with designing, for example, which safe and non-toxic materials are used and how the product can be easily disassembled for repair, reuse and remanufacturing. As circular economy aims to decouple growth from the use of virgin raw materials and natural resources, eliminating pollution and waste (there is no waste in nature; everything is raw material), a circular design approach can be regarded as a tool to achieve these goals.

Circular design plays a key role in a systemic transition towards a circular economy and no matter what lifecycle stage is in question, the change starts with design.

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[14] Adapted from: Ellen MacArthur Foundation & Martin Geissdoerfer *et al*. in *The Circular Economy - a new sustainability paradigm? Journal of Cleaner Production,* (2017).
[15] Other commonly used term is eco-design although eco-design often aims for more environmentally friendly design within the current linear system and it excludes circular business model development.

Circular design, instead, takes a lifecycle view covering materials and chemicals, manufacturing, logistics, business model, use, and end-of-life (or second life) stages. It aims for long-term value maintenance through circulating products and materials endlessly in biological (renewable materials) or technical (non-renewable) cycles using only clean energy. Why is business model development regarded as part of the circular design process? Because the product needs to be designed in a way that enables, for example, maintenance and repair services, selling the product as a service, the use of sharing platforms, and eventually taking the product back for disassembly and remanufacturing purposes.

Accordingly, circular design is much more than just design; it becomes a strategic tool steering the way business is conducted. It is necessary, therefore, to establish circular economy as a strategy at company level to maximise the business benefits of the circular design approach.

Currently there are no industry-wide circular design guidelines for electrical and electronic products which would facilitate better plastics circulation.[16] At the moment, the interest is in recycling valuable metals, but as the world is moving towards circularity and the amount of EEE is growing fast, plastics need to be used in a more circular fashion. Leading companies have addressed the issue by developing their own set of company-level circular or eco-design principles and processes along with concrete goals to move towards a circular way of operating, thus ensuring they are in the best position to meet the resource-scarce future. A company-level commitment is a "must-have" in order to implement all the other circularity aspects along the lifecycle.

Case Study: EcoDesign at Philips

Philips has developed an EcoDesign process with six key Green Focal Areas for improved environmental performance – Energy, Packaging, Substances, Weight and Materials, Circularity, and Lifetime.

The Circularity focal area is about recovery, reuse and increasing recycled materials in the products as well as designing for easy disassembly, upgradability, recyclability and product-as-a-service business model.

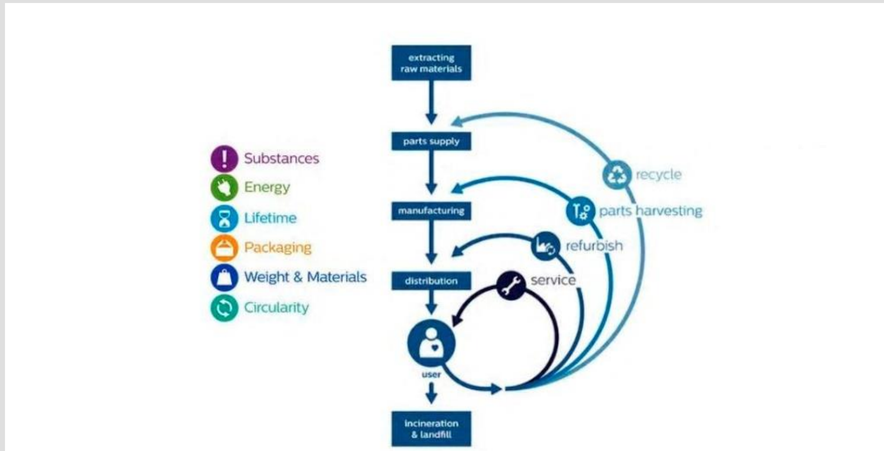
Philips operates both in B2B and B2C sectors. In B2B operations, Philips has set a target for closing the loop by 2020 through getting all its healthcare equipment back for remanufacturing. A target is to use only recycled plastics in inner parts of consumer electronic products by 2025. Along with more colour options and visual quality, the amount of recycled plastics can be increased to external parts.

Philips aims to shift its business model from ownership to providing solution-driven services. In practice this means moving from selling to harnessing the product-as-a-service model and providing maintenance and repair services to customers.

As a result of its circular design work, Philips has introduced a number of consumer lifestyle products made of recycled plastics (recycled content varying from 13%–95%), such as vacuum cleaners, coffee machines and steam irons.

[16] *Designing with recycled plastics guide* offers info and case examples of companies using recycled plastics in their manufacturing, (2015). https://www.partnersforinnovation.com/media/Guidelines-designing-with-recycled-plastics.pdf

Figure 2: The circular economy



Case Study: Design for Environment at Dell

A central part of Dell's approach is to consider sustainability at every stage of a product's lifecycle – from the initial design concept to its use and eventual recycling. Dell has named the process "Design for Environment". The goal is to achieve zero waste by ensuring that every part of the product can be reused or recycled. Dell's design principles consist of six key areas:

1. Recyclability of materials;
2. Modularity: The majority of components found inside Dell products are easily removable, with standardised parts. This makes it easier to reuse or recycle them;
3. Easy disassembly: all parts are easily separable with commonly found tools;
4. Minimal glues and adhesives: Glues and adhesives can create processing challenges for recyclers, so Dell has come up with other methods, such as innovative snap fits, to accomplish the same design goals;
5. Restrictions on paints and coatings: Dell prefers integral finishes instead of exterior coatings, which can interfere with the recycling process or degrade certain plastics during processing. If paint is the only option, Dell uses paint that is compatible with recycling;
6. Single-access service door: easy access for repair and recycling.

In 2014 Dell set up a closed-loop recycled plastics supply chain. This means that Dell can recover plastics from old computers and process them into new parts for new products. Dell's closed-loop plastic parts are nowadays used in over 100 different products.

2.2 Lifecycle stage: materials and chemicals

> "Manufacturers should agree on the type and amount of polymers they use in their products."
> – Energy Authority Finland.

Decisions on material and chemical use are made at this lifecycle stage. There are various ways to contribute to circularity; for example, through decreasing different polymer types, phasing out chemicals and using recycled plastic in production.

2.2.1 Harmonising the use of plastics

For recyclers, one of the current barriers to processing plastics coming from electrical/electronic products is the sheer number of different polymers:

> "There are roughly around 500,000 different polymers in the world; 470,000 of them are used in technical products. This is the reason we don't process WEEE plastics." – Fortum.

Presently there is no focus on the variety of components composition. The biggest material use in both weight and CO_2 impact is steel and the second one is plastic. This includes the thermoplastic materials PP, PS and ABS, plus smaller amounts of engineering plastics (that can be remelted and reused) and PUR, which is a thermoset material that cannot be remelted. PUR is, for instance, used in refrigerators as a very effective insulation material but would require chemical breakdown to be recycled for use in the same application. Instead, PUR is recycled into new applications such as insulation panels and noise absorbers or as a powder for absorbing spills (e.g. oil spills) on land or in water. Thermoplastic components, on the other hand, are sorted out in the recycling process by polymer type and remelted and reused in different applications.

One feasible solution to reduce the huge variety would be manufacturers agreeing on the types of plastics and different polymers they use in their products; this would scale up more pure material stream volumes and make it financially more viable to invest in new recycling technologies. The PolyCE[17] (Post-consumer high-tech recycled polymers for a Circular Economy) project's recommendation is to use polymers with known high recyclability rates, such as ABS, HIPS, PS, and PP, in parts such as housings, frames, etc. which are significant also in terms of weight.

Another opportunity is to harness the platform design approach, which means that parts are standardised so that they can be used in several products. The production volume of the platform is much larger than the volume of the single product. This means that there is better economy in planning circularity, a longer lifetime, more options for repair, etc.

[17] https://www.polyce-project.eu/

As one interviewee suggested, there should be a Roundtable on EEE Plastics similar to the Roundtable on Sustainable Palm[18] with the aim of bringing together actors across the value chain to agree on polymer types used as well as to create common Circular Design Principles.

Case Study: Novo Nordisk harmonising plastic use

Novo Nordisk decided to use as few types of plastic in their insulin pens as possible. For one of the prefilled devices (insulin pens that are disposed of when empty), only PP and POM plastic materials were used. The two plastic types are easily separated utilising their different density. This means it is realistic to make an automatic recycling system where the pens are broken down mechanically into small pieces and then sorted in a liquid separator resulting in fairly pure material fraction that can be reused. The major challenge in recycling is the return logistics – the diabetic patients could, for example, hand in their used pens at the pharmacy when picking up new supplies. Pharmacies in Denmark already receive many types of medical waste like pill boxes, unused medicine and insulin pens. But for economic (and safety) reasons the pharmacy does not sort the waste, but delivers it to an authorised waste handler. If the economic model is right and medical products are designed with recycling in mind, pharmacies and/or waste handlers could sort the waste products allowing for very pure material fractions.

2.2.2 Material identification

Different plastic types are marked, but according to the interviewees the markings are not correct, which results in a supply chain domino effect.

> "Kuusakoski bought an expensive recycling processor from Germany which could read the die cut identification code in a piece of plastics to improve separation. We started getting reclamations from our clients that the plastic we sold them didn't correlate with the markings, which, in turn disrupted their processes. It turned out that the manufacturers' identification codes were not correct, but they didn't care about it. We had to stop using the processor." – Kuusakoski Recycling.

The marking of plastics is done during production where an imprint in the production mould leaves a mark signalling the plastic type. However, if the same mould is used with another type of plastic, the marking will be wrong. An alternative technology for material identification is near infrared detection (NIR), where the reflection of long-wave light can be used to identify the type of plastic.[19] This works well for many light-coloured types of plastic, but the technology does not work for black plastics, which are very common in plastics for electronics. The black colour agent (typically soot) absorbs the infrared light and the NIR detector will not register any reflection. This leads to a problem for plastic recyclers, since it is difficult for them to distinguish between black

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[18] Roundtable on Sustainable Palm has developed a set social & environmental criteria that companies must follow if they want to produce Certified Sustainable Palm Oil.

[19] A. Turner, Black plastics: Linear and circular economies, hazardous additives and marine pollution, *Environ. Int., vol. 117*, no. April, pp. 308–318, (2018); O. Rozenstein, E. Puckrin, and J. Adamowski, Development of a new approach based on midwave infrared spectroscopy for post-consumer black plastic waste sorting in the recycling industry, *Waste Manag., vol. 68*, pp. 38–44, (2017).

plastic from electronics and from household waste (e.g. food trays). The risk is that unwanted substances, such as flame retardants and heavy metals, find their way from electronics plastics into plastics used for food packaging. However, research projects are ongoing to develop a refined technology using midwave infrared detection (MWIR) that will be able to work with black plastic.[20]

2.2.3 Phasing out chemicals and additives

Apart from the basic chemical building blocks, a range of other chemicals can be found in plastics. These other chemicals are referred to as additives and serve purposes such as:[21]

- Functional additives (stabilisers, antistatic agents, flame retardants, plasticisers, lubricants, slip agents, curing agents, foaming agents, biocides, etc.);
- Colourants (pigments, soluble azocolourants, etc.);
- Fillers (mica, talc, kaolin, clay, calcium carbonate, barium sulphate);
- Reinforcements (e.g. glass fibres, carbon fibres).

Furthermore, there can be residual chemicals from the production process – for example, catalysts like antimony or uncured monomers (the basic building blocks that make up the polymer chains).

For electronic products the most common plastic types are ABS, HIPS and PC. Additives that draw attention in recycling include fire retardants (e.g. Brominated Flame Retardants, or BFRs), heavy metals (e.g. lead for stabilisers and pigment, cadmium for pigment, and antimony for catalysing flame retardant), and reinforcements for improved stiffness. The BFRs represent the biggest challenge to recycling since they are widely present in much WEEE plastic, in particular, cathode ray tube (CRT) casings. The basic plastic types are simple to separate using density separation[22] but the additives are more difficult to deal with. The WEEE directive set rules for fire protection, which means that the plastics have to go through mechanical recycling as opposed to energy recovery (incineration) that can cause unwanted pollution.[23]

Antimony is rare element in the earth crust and is mainly produced in China. Need is expected to rise in the coming years, making it more attractive to recover the antimony through the recycling process.[24]

According to recyclers, various chemicals – especially a group of BFRs – comprise one of the biggest barriers for EEE plastic recycling. Additives, such as glass fibre and heavy metals, also pose a challenge for recyclers. Phasing out chemicals and additives

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[20] Ibid.
[21] J. N. Hahladakis, C. A. Velis, R. Weber, E. Iacovidou, and P. Purnell, An overview of chemical additives present in plastics: Migration, release, fate and environmental impact during their use, disposal and recycling, *J. Hazard. Mater., vol. 344,* pp. 179–199, (2018).
[22] A. Haarman and M. Gasser, *Managing hazardous additives in WEEE plastic from the Indian informal sector,* no. June, (2016).
[23] L. Tange, J. Van Houwelingen, W. Hofland, F. Kohl, M. Kearns, P. Salemis, and N. Mendad, *Recycling of plastics containing flame retardants in electronic waste, a technical and environmental challenge for a sustainable solution,* PMI Conf., (2012).
[24] M. Schlummer and F. Wolff, *Recovery of Polymer Additives from WEEE Plastics,* CloseWEEE Workshop, Freising, (2018).

is to a large extent a design question. For instance, the CLOSEWEEE[25] project found that flame retardants used in TV back covers could be eliminated through changes in design, which makes recycling of back covers easier.

2.2.4 *The PolyCe Guidelines on chemicals and additives*

The PolyCe Project[26] has created a set of guidelines on the use of chemicals and additives to improve the circulation of plastics:

- Use only common and easily recyclable plastics (ABS, PC, PC/ABS, PP, HIPS, PA);
- Do not use thermosets. If thermosets are necessary, they should have another density than the common plastics used;
- Do not use elastomers. If elastomers are necessary, they should have another density than the common plastics used;
- Do not use halogenated polymers (e.g. PVC, PTFE);
- Do not use heavy-metal-based lubricants and plasticisers;
- Do not use polyoxymethylene (POM);
- Do not use silicone compounds, oils or greases;
- Do not use montanic acid ester;
- Avoid coatings (painting, lacquering, plating, galvanizing);
- Do not use glass fibres or carbon fibres. If reinforcement is needed, prefer talc;
- Avoid moulding different plastic types together by 2K or xK processes;
- Use one single polymer in plastic casing parts >100g;
- Avoid using connections that enclose a material permanently.

Case Study: Designing out chemicals

Oticon A/S, a hearing aid manufacturer based in Copenhagen (Denmark), has enforced extra specifications: for example, a ban on the use of phthalates and natural rubber latex. Working with the restricted list ensures full transparency on the use of hazardous substances, compliance with relevant directives, and the opportunity to set a higher bar than the external required or recommended standards. They are developing a risk-based approach where material compliance is not only secured by supplier declarations, but also via material analysis for high-risk materials.

FischerLighting has used recycled plastic in its lamp. To give plastic more strength, talc is added instead of glass fibre, which makes recycling easier.

There is a special focus on non-toxic materials at BODY BIKE International: for example, a handlebar coming from a German supplier has to be without any toxic substances, to protect the user (a lot of skin contact) as well as the environment.

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[25] CLOSEWEEE: http://closeweee.eu/
[26] A. Berwald, *PolyCE – Deliverable 2.2 – Requirement-specific priority plastics guide*, (2018).

2.2.5 Increasing the use of recycled plastic

Plastics can be recycled either mechanically or chemically; incineration does not count as recycling. Chemical recycling breaks the material down to a molecular level and produces high-quality material comparable to virgin plastics but is an expensive method still lacking economic viability. The prevailing view is that mechanical recycling is the primary method, which can be complemented by chemical recycling.

According to our interviewees, using recycled plastic requires a different design approach and different processing than virgin plastic and can be challenging in the beginning. However, interviewed brands regarded this as only one R&D challenge amongst others; when there is a company-level commitment to using recycled plastics, required know-how can be built along with required changes in the processes to ensure a high quality of plastic.

Another challenge to overcome is the chicken and egg problem, a situation whereby recyclers do not process plastics if there is no market for them and brands cannot buy recycled plastics because there is no supply. Big brands can take the lead on this and start working with plastic recyclers to find the right quality and make a commitment to buy the processed plastics, as the carmaker Volvo has done:

> "We encountered a 'catch-22', where we wanted reused plastics but the providers didn't have it in the right quality. Then there's the reuse business that doesn't process it as they don't think there's a market for it. Therefore we wanted to set that ambition [at least 25% recycled plastic in each new car] to show that there's a market, we want this." – Volvo.

Besides bringing many environmental benefits, using recycled plastics also makes business sense; scaling up the volumes results in bigger savings.

> "The most important driving force is that it is green, which helps improve our overall environmental performance by reducing impacts from materials, and something which is used to market certain products. But using recycled plastic can also be a cost benefit, as it is often cheaper." – Electrolux.

The French ESR[27] has created a tool called Reeecyclab[28] for producers to evaluate the recyclability of a product, test alternatives and identify areas for improvement.

[27] https://www.eco-systemes.fr/en/all-about-eco-systemes
[28] https://reeecyclab.eco-systemes.com/?locale=en

Case Study: Working with recycled plastics

Electrolux has established an Internal Recycling Taskforce, which includes representatives from each Electrolux sector, purchasing, R&D, production and product lines to define the commitment's scope, targets and action points. The main activities are to find reliable and high-quality material suppliers and to identify the best opportunities within each product category for replacing virgin materials with recycled materials – either within the existing design or by adapting the design for recycled material.

Electrolux has set a target to replace virgin plastic with recycled plastic and increase the amount of recycled plastic in products to 20,000 tonnes per year. Electrolux has calculated that CO_2 emissions resulting from the production of virgin plastic are equivalent to the emissions from operations and transport activities combined, so the positive environmental impact from recycled plastic is significant.

Sony has developed SORPLAS™, plastic made of waste optical discs and leftover film from Sony and other factories as well as post-consumer materials, such as plastic water bottles. SORPLAS is used in TVs and cameras. The flame retardant in SORPLAS is sulphur-based, which allows much higher use of recycled plastic in the product than conventional flame retardants. According to Sony, sulphur-based flame retardant does not weaken the quality of plastics, so it can be recycled several times without the loss of high quality.

At least 25 percent of the plastics used in every newly launched Volvo car will be made from recycled material from 2025 onwards. As the lifespan of the car can be long, Volvo is also using recycled plastics from other industries, for example, the packaging industry.

Plastix A/S is a sustainable cleantech plastic fibre recycling startup company that targets the niche of waste stream marine plastic pollution, such as fishing nets (HDPE) and ropes (some are PP), and helps turn it into oceans-based plastic products to supply the automotive industry, high-end furniture industry, packaging industry and brand owners.

Case Study: Benefits – plastics replacing other materials

Volvo uses around 200 kg of plastics (16–17% of all materials used) in each car. Replacing heavier materials, like steel, with plastics makes the vehicle lighter. A lighter vehicle means less fuel consumption and smaller carbon footprint. In addition, using plastics instead of leather inside the car also means emission savings.

Ohmatex is a smart textile technology company and a good example of how the use of other materials like copper and aluminium metals for electrical conductors can be minimised when integrated into garments. Ohmatex produces electrical-conducting textiles with built-in electrodes and electrical wires based on polymer fibres. The use of metal is much less than if separate wires were used.

2.3 Lifecycle stage: product design – reparability, upgradability, modularity and ease of disassembly

> "The point of manufacturing and design is where it all starts. Whatever they do at that point will determine how the product will be used, re-used and re/upcycled." – MatKon.

2.3.1 Reparability, upgradability, modularity and ease of disassembly

Focus on material efficiency has been part of companies' design strategy for a long time. Reparability, upgradability, modularity and ease of disassembly (RUMED) are circular design strategies which are less implemented but they play a vital part in the following:

- Extending the lifespan of the product
- Enabling worn-out/broken parts to be replaced instead of replacing the entire product
- Enabling software to be upgraded without having to buy a new product
- Enabling remanufacturing through easy disassembly, thus being able to recover components without destroying them.

There are many business benefits for applying these RUMED strategies; from the customer perspective it creates loyalty and trust towards the brand. The overall customer experience is improved when the product is durable, spare parts and upgrades are available, and repair service works seamlessly.

> "The overall experience of a product that unfortunately breaks but then is quickly repaired often creates a bigger customer satisfaction than just replacing the broken product. Many customers really value the fact that the product is possible to repair and not wasted. So there's real a business advantage to provide this service." – Electrolux.

RUMED also contributes to decoupling growth from the use of virgin raw materials and natural resources: business can grow through providing maintenance and repair services. As mentioned previously, getting components and material back for reuse or remanufacturing instead of buying virgin material also makes economic sense when scaled up properly.

Case Study: Harnessing RUMED strategies

Philips offers repair manuals and software updates and sells spare parts in its online shop. They have also set up an online DIY shop, which offers guidance on repairing Philips products.

Dell has phased out glues and uses standardised snap fits for ease of disassembly. They have also standardised components for easier reuse.

Electrolux designs for reparability and provides repair services for the customers.

Fujitsu follows 3R design principles that focus on reduce, reuse, and recycle. Fujitsu is making efforts to improve resource efficiency, which is made possible by designing products to be lighter and smaller, using recycled plastics, reducing the number of parts, enhancing ease of disassembly and improving recyclability. In addition, Fujitsu's own 3D Virtual Product Simulator (VPS) is used during the product design process, to test the steps involved and the convenience of product assembly and disassembly before creating prototypes.

Oticon's products are designed for repair. The speakers in RITE instruments have filters to protect them from earwax and to prolong the lifetime of the speaker unit for the ear. The end users can change the filters as well. The outer plastic shell can be exchanged if it breaks. Plastic battery drawers are handled by end users when changing small batteries. They are designed with high strength material to reduce the risk of breaking, but they are also designed to break first, before more critical components get destroyed when overloaded. Battery drawers can be replaced if they are overloaded.

Fischer Lighting supplies new LED lighting units to be retrofitted into existing lamps, easing the transition from older types of lighting sources.

BODY BIKE International produces spin bicycles for gyms. The bicycles are made from stainless steel and partially recycled plastic and are exposed to extensive wear and corrosive environment (sweat). The bicycles are therefore designed for easy disassembly to make repair easy and realistic. Old bicycles are refurbished and sold to private customers.

B&O works in close collaboration with DTU and Aalborg University on a readiness assessment, extended lifetime, improved durability and circular economy to include more design rules in their future design work. Design rules such as design for disassembly, design for reparability, design for environment, and design for reducing harmful substances are being introduced into the design stage.

2.3.2 Collaborating with supply chain partners

Value chain collaboration could and should be strengthened to increase plastics circulation. As the examples of Dell, Fujitsu and Philips showcase (see case study below), bringing manufacturers and recyclers together enables mutual learning: manufacturers can improve their internal design and manufacturing processes to improve, for example, ease of disassembly of plastics, and recyclers can develop and offer tailored plastic grades for manufacturers according to specifications.

> "Regarding plastic and circularity, partnering up with others is a must. In circular economy you have to do that, it is SDG 17 (the UN Sustainable Development Goal: "Strengthen the means of implementation and revitalise the global partnership for sustainable development") that we relate to and discuss this with our partners. So yes, partnerships – absolutely." – Volvo.

> "In order to move forward in this industry, as in literally any other, collaboration is needed – we need to drastically cut the distance between each end of the value chain." – MatKon.

Case Study: Learning from each other

Since setting up closed-loop recycling for plastics in 2014, Dell has used nearly 11 million kg of recycled plastic, and their target by 2020 is to use nearly 50 million kg of recycled plastic and other sustainable materials in their products. Dell also collaborates with their partners to learn what types of design and polymer choices enable efficient recycling.

Fujitsu organises tours for designers in their recycling centres to facilitate discussion and learning between the two parties. Designers can then apply these learnings to their design processes to promote disassembly and recycling.

Philips uses co-creation design methods with recyclers and recycled material suppliers to build common expertise on how to improve the quality of recycled plastics.

Fischer Lighting collaborated with 3XN, a Danish architectural company, to design an award-winning lamp with recycled plastic.

The plastic was supplied by Plastix A/S, a Danish cleantech recycling company specialised in converting fibres – primarily used fishnets, trawls, and ropes – into high-quality, virgin-like rHDPE and rPPC green plastic raw materials. This presents a solution to a substantial waste problem; contributes to a more circular economy; reduces the amount of waste to landfills, ocean plastic waste, and CO_2 emissions; as well as prevents a valuable resource from being lost. Plastix also provides consultancy services to help customers transform high-quality material into innovative, and in this case, modular, products.

2.4 Lifecycle stage: Circular business model

2.4.1 Introduction to Circular Business Models

Circular business models (CBM) refer to ways of doing and developing business through decoupling growth from the increasing use of virgin raw materials and natural resources. Unlike the linear business model which is based on selling high volumes with faster purchase cycles ("sell more, sell faster") and consequently exhausting our natural ecosystems and material reserves, CBM ideally aims for one-planet business logic, i.e. sustainable growth that operates within planetary boundaries. One way to explore this critical topic is Earth Overshoot Day,[29] which calculates each year the date by which the planet's ecological resources and services have been used up (in 2018 the global Earth Overshoot Day was 1 August), and the rest of the year we operate in a growing ecological deficit. CBMs, therefore, play an important role in our effort to move towards a sustainable way of doing business.

Circular business models can be classified in the following way:[30]

1. *Access and performance model*: in this model, the user can access and use the product without owning it, also called a "product-service system";
2. *Extending product value*: a business model whereby the manufacturer reuses or remanufactures old products through take-back programmes;

[29] Earth Overshoot Day: *https://www.overshootday.org/*
[30] Nancy M.P. Bocken *et al.* (2016): Product design and business model strategies for a circular economy in *Journal of Industrial and Production Engineering*.

3. *Classic long-life model and encourage sufficiency*: focus is on long-lasting and durable products and offering maintenance/repair services to support the user's ability and willingness to keep the product in use as long as possible;
4. *Extending resource value*: this business model refers to turning waste into useful raw material and decreasing or replacing virgin material altogether;
5. *Industrial symbiosis*: this model refers to close physical proximity and collaboration between companies.

Although CBMs are often presented in the form of the above list, in reality they overlap and complement each other, thus forming "hybrid" CBMs. For example, designing and manufacturing high-quality products (No 3: Classic long-life model and encourage sufficiency) is a prerequisite for access and performance model (No 1). For the company, it is always important to explore all CBM opportunities to maximise the circularity of operations.

Case Study: Moving towards a circular business model

Philips wants to move from ownership and selling the product to the access and performance model, which enables them to retain the material ownership for reuse and remanufacturing purposes.

Volvo's new mission is "Freedom to Move" and the company wants to become a service provider creating closer relationship with the consumer. In 2018 Volvo launched M, a service providing on-demand access to cars and services through an intuitive app. Learning the user's preferences and behaviour, Volvo's software development aims to give a feeling that the car understands the user through the personalised application. Through the service model, Volvo is able to reuse and remanufacture car parts more easily.

MatKon Group consists of MatKon Refurbish, MatKon ProService and MatKon Data and specialises in dealing with manufacturers, resellers and operators of electronic products (e.g. IT/IP equipment, vacuum robots, coffee machines).

They offer services for the telecom industry by repairing and refurbishing used routers and TV boxes. MatKon collaborates with Kirppu (specialised flea markets, 13 stores in Denmark), where you can buy a refurbished PC with a 15% buy-back price, if returned at end-of-life. The recycle and resell concept extends the lifetime and the value of the product.

Bang & Olufsen (B&O) produces expensive high-end audio and video equipment. The B&O products represent design icons of high value and there are third-party shops specialising in refurbishing used B&O products to sell them again.

2.5 Lifecycle stage: end-of-life and reverse logistics

2.5.1 Introduction to end-of-life and reverse logistics

Organising reverse logistics to get products/material back for reuse and remanufacturing purposes often goes hand in hand with setting up a CBM (circular business model).

Considering the product's end-of-life as part of the design process is a crucial element of making circulation happen. For example, removing glues makes it easier to recover components.

In a linear economy, companies have optimised their production lines and logistics as a one-way street, being efficient in transporting products out to be sold; but taking products or materials back for reprocessing requires a different structuring of operations. Getting products back (a so-called take-back programme) for reuse, remanufacturing and finally for recycling requires reverse logistics, facilities for disassembly, and designing and setting up a system for remanufacturing. These operations can be performed either by the company itself or through setting up partnerships.

Case Study: Organising end-of-life stage

Fujitsu has set up recycling centres across Japan to take back old ICT products, where products are disassembled, sorted and recycled. Materials recognition equipment has been introduced for plastics that are difficult to discriminate between, so as to allow the complete segregation of different types of plastic. Plastics are sorted into 20 different streams for remanufacturing and recycling purposes.

Inrego has built a business based on the end-of-life stage and set up an economically feasible take-back system. Inrego extends the lifespan of old computers, mobile phones and other IT equipment through buying them back, erasing all data, and repairing and upgrading them for a second lifecycle. Products are then sold or rented (with a warranty) to customers.

2.5.2 From recycling towards circulation

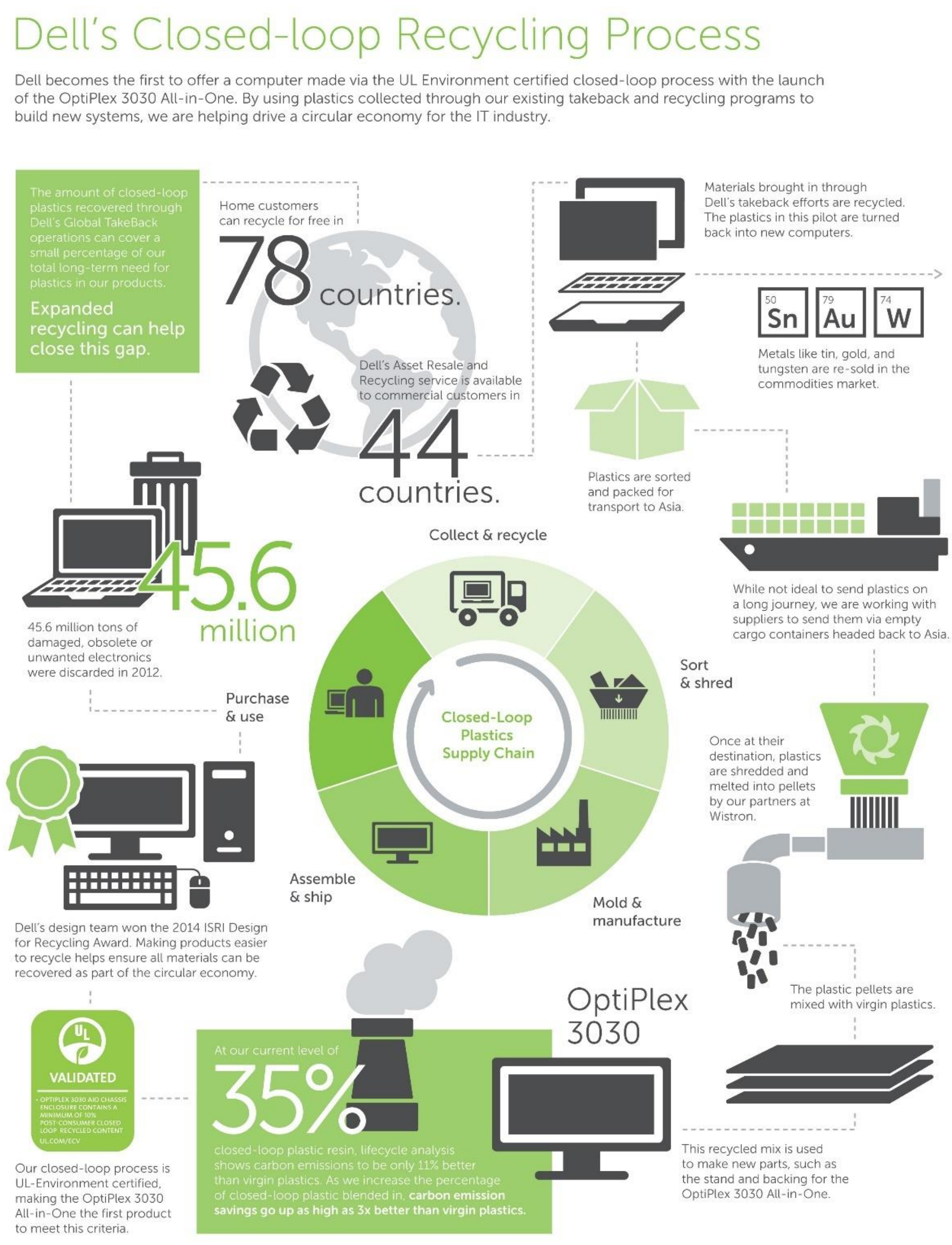
In a circular system, the ultimate goal is to set up a system whereby material is reused in the same product over and over again – for example, plastics collected and processed from computers are processed and used in computers again. This is the crucial difference between recycling and circulation; recycling currently means value loss (in terms of leakage and quality) and often the recycled material is lower quality, thus ending up in a lower quality product. Circulation, instead, aims for maintaining value over multiple lifecycles. Regarding the multitude of different plastic types, a closed-loop system removes the challenge of unknown plastic types.

Case Study: Setting up reverse logistics

Philips' reverse logistics services include deinstallation of the healthcare equipment and transportation to a refurbishing factory. Philips aims to close the loop by 2020 through getting all its healthcare equipment back for remanufacturing, which will enable plastics to be processed at higher volumes and become more economically viable.

Dell set up a closed-loop plastic recycling process in 2014 (see Pic. 2). To date Dell has used nearly 50 million kg of recycled plastic in their products.

Figure 3: Dell's Closed-loop Recycling Process



Source: http://www.electronicstakeback.com/wp-content/uploads/Dells-closed-loop-recycling-large.jpg

Case Study: Benefits of closed-loop plastics

In addition to long-term value maintenance, a closed-loop system generates significant environmental benefits. In 2015 Dell conducted a study (Table 2) which found that closed-loop ABS plastic resulted in avoided environmental costs of USD 1.3 million annually compared to the use of virgin ABS plastic. Accordingly, the natural capital net benefit of closed-loop ABS vs. virgin ABS was 44% (natural capital calculations include a range of environmental metrics, such as climate change, ecotoxicity, water pollution, respiratory effects, fossil fuel depletion, smog, air pollution and human health)[31]. According to the same study, avoided environmental costs would be USD 700 million/per year if the entire computer sector would use recycled ABS instead of virgin ABS plastic.

Table 2: Dell Study on avoided environmental costs: Natural Capital Values of Environmental Impacts: Virgin ABS and Closed-loop ABS

Environmental impact	Virgin ABS (in USD)	Closed-loop ABS (in USD)	Net benefit of closed-loop ABS
Human health			
Human health	-1,045,000	-392,000	+62%
Respiratory effects	-186,000	-172,000	+8%
Energy and fossil fuels			
Climate change	-1,173,000	-686,000	+42%
Fossil fuel depletion	-60,000	-21,000	+65%
Air pollution			
Smog	-538,000	-517,000	+4%
Air pollution	-82,000	-78,000	+5%
Water and land pollution			
Water pollution	-44,000	-28,000	+36%
Ecotoxicity	-14,000	+134,000	+1,057%
Cumulative	*-3,143,000*	*-1,760,000*	*+44%, USD +1,383,000*

[31] https://i.dell.com/sites/doccontent/corporate/corp-comm/en/documents/circular-economy-net-benefits.pdf?newtab=true

3. Future of plastics and recommendations

This chapter looks into the future horizon: what changes or what should change and by whom in order to transition towards a circular economy? The list of six recommendations is provided for further action.

> "The Circular Economy and the UN Sustainable Development Goals will radically change the way we operate our businesses. We can, in the very near future, expect legislative frameworks requiring design for disassembly, design for recyclability, deposit and return systems, extended producer responsibility, tracking and marking systems for traceability, and perhaps even requirements of using mono-polymers, instead of mixing different types of polymers, which currently poses a barrier for recyclability." – Plastix A/S.

3.1 What will the future look like?

It is evident that a quantum leap towards better design and material management is needed quickly.

Given the important and manifold role of plastic in electronic/electrical products and the automotive industry, plastic use is not going to decrease. Fossil fuel-based plastic will gradually be phased out in parallel with increasing R&D and testing on bio-based plastic. Of 1.2 million tonnes of WEEE plastics in the EU, up to 50% could be recycled instead of the current 20%.[32] If all returned WEEE plastics were recycled in Europe, the estimated CO_2 emission reductions would be over 2.5 million metric tonnes per year.[33]

The first EU plastic strategy was implemented in early 2018, requiring 50% recycled plastic content in packaging material by 2025 and 55% by 2030. There could be a similar target for CEEE, which would speed up the market transition significantly.

In addition to a huge market potential, many interviewees mentioned customer demand as an important driver. No doubt this demand will only grow in the future.

> "In the future there will be more demand from the consumers to have a circular economy in place for products. It will be a big movement in society." – BODY BIKE International A/S.

Whilst the case studies in this report show enormous potential for developing design practices according to circular principles, the fact is that consumers, too, need to rethink their own consumption.

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[32] European Electronics Recyclers Association Position Paper: Weee Plastics Recycling Strategy Proposals, (2017).
[33] Ibid.

> "If we want to move towards a circular economy, we need to radically think about our own consumption. It has been said that this is a materialistic era – on the contrary; our relationship with material is twisted. We don't care to fix and if we don't like the product we think that we can always do KonMari (a trend of getting rid of "stuff" at home). Back in the 70s we still repaired products. Recycling is not a solution, it is a last resort before incineration." – Energy Authority.

In a similar vein, the rise of a sharing economy contributes to the consumer's role: on one hand, sharing electrical/electronic equipment increases the use rate of a single product; on the other, increased use by multiple users calls for more durable products.

3.2 Recommendations

Circular design principles

Embedding a circular economy vision and approach into the company's strategy is a first step every company could and should take. Developing and implementing circular design principles is a concrete way to execute the strategy and it also ensures that the company is future-fit in a changing and resource-scarce business environment.

Roundtable for plastics circulation

Circular design can and should play an important role at each stage of the lifecycle. A roundtable – a high-level platform bringing together companies and value chain actors to create sector-wide Circular Design Principles – is crucial in order to capture economic value that is currently lost due to linear design. Taking a broader view; a great many current challenges and linear practices could be addressed through a closer value chain collaboration. Brands could learn from recyclers and take these learnings into their circular design processes and vice versa; recyclers could tailor their offerings based on the specific needs of each customer.

In addition, there are currently a number of different ways of handling and recycling plastics; there is a need to set up bigger clusters for side stream management to drive up volumes and economic viability.

Various networks exist, such as WEEE Forum[34] and Next Wave[35] and many others, that could join forces and take the lead on this. Producer responsibility organisations in the EU member states could also be catalysts of change; for example, ESR[36] has created an ecosystem around the WEEE industry to develop more efficient and effective collection and treatment systems in France.

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[34] http://www.weee-forum.org/

[35] https://www.nextwaveplastics.org/

[36] https://www.eco-systemes.fr/en/all-about-eco-systemes

Material identification and circular material choices

One prerequisite for the highest possible value capture is material identification. Incorrect markings on plastics have resulted in a situation whereby recyclers don't trust the markings and therefore different types of plastics are not separated even if it were technologically possible.

Coupled with the issue of identification is the opportunity to harmonise plastics use. Going through different polymer types used in the production and shifting to the most commonly used polymers is an effective way to contribute to recycling. However, this inventory should be done in collaboration with the sector, as it has a direct impact on recyclers. If recyclers knew what polymer types were coming in, they could make necessary investments in novel technologies, thus resulting in more consistent quality material. Furthermore, designing out chemicals and additives improves circulation opportunities significantly.

Legislation

A requirement for using recycled content would speed up the market transition towards circularity. In addition, requirements for circular design principles, especially reparability, modularity, upgradability and ease of disassembly could be first encouraged in the form of sector-wide principles and gradually formulated into requirements. Removing existing barriers, such as transporting e-waste across borders within the EU, is equally important. Nordic countries are well positioned to build a Nordic Cluster of harmonisation for a take-back recycling system to support scalability.

Embedding environmental calculations into the decision-making process

To operate within planetary boundaries it is necessary to ensure that products are designed, manufactured and circulated in such a way as truly takes us closer to a circular economy. Calculating avoided environmental costs provides a good business case and foundation for decision-making when starting a circular journey.

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Sammenfatning

80 % af produkters miljøpåvirkning og 90% af omkostninger til produktion er resultat af beslutninger foretaget i produktets designfase. På nuværende tidspunkt er de fleste elektriske og elektroniske produkter (EEE) ikke designet med henblik på recycling endsige til genanvendelse. Plast i disse produkter tegner sig for ca. 20 % af materialeforbruget, og gennem bedre design kan der opnås betydelige miljømæssige og økonomiske besparelser. For eksempel kan genbrug af plast i et elektrisk eller elektronisk produkt reducere miljøpåvirkningen for et enkelt produkt med over 20 %. Hvis alle WEEE plastmaterialer i Europa blev genanvendt, vil den estimerede CO_2-reduktion være på over 2,5 millioner tons om året.

Der eksisterer teknologiske løsninger og cirkulære designmuligheder, men af forskellige årsager er de endnu ikke implementeret. Nogle af udfordringerne, som f.eks. let adskillelse kunne løses gennem bedre kommunikation og deling af erfaringer på tværs af værdikæden. Desuden forventer forbrugere i stigende grad at virksomheder går foran og tilbyder mere bæredygtige løsninger.

I stedet for at skabe WEEE (Waste Electrical and Electronic Equipment) skal vi fokusere på at udvikle CEEE – Circular Electrical and Electronic Equipment.

De følgende case-eksempler viser, at der er store forretningspotentialer i at forbedre plastcirkulationen. Kunderne forventer i stigende grad, at virksomheder tager føringen og tilbyde mere bæredygtige valg.

Det endelige mål bør være at designe og etablere et system, der muliggør cirkulation. Med andre ord, tager produkterne tilbage og oparbejde materialerne til de samme produkter igen og igen.

Formålet med denne rapport er at påvirke EEE sektoren mod cirkulær økonomi. Rapportens case-eksempler viser hvordan de forskellige livscyklusfaser kan designes så recirkulering af plastic bliver mulig og giver forretningsmæssig mening. Det er tid til at tage et spring i styringen af materialestrømmene og opskalere de cirkulære løsninger i hele branchen.

Anbefalinger

Cirkulære design principper

Indarbejdning af cirkulære økonomiske visioner og tilgange i strategien er det første trin for alle virksomheder. Udvikling og implementering af cirkulære design principper er en konkret måde at operationalisere strategien, og det sikrer desuden at virksomheden er bedre rustet til en omskiftelig fremtid præget af ressourceknaphed.

Rundbordssamtaler om recirkulering af plast

Cirkulær design kan og skal spille en vigtig rolle i alle livscyklusfaser. Rundbordssamtaler er højniveau platforme, som bringer virksomheder og andre værdikæde-aktører sammen for at skabe brancheorienterede cirkulære design principper. Sådanne rundbordssamtaler er afgørende for at modvirke det økonomiske tab som lineær design afstedkommer. Ved at anlægge et bredere perspektiv vil mange af de nuværende udfordringer og lineære praksisser kunne adresseres gennem et tættere værdikædesamarbejde. Udviklere og producenter kan lære fra recyclere og bruge erkendelserne i deres cirkulære design principper og vice versa; recyclere kan skræddersy deres tilbud baseret på de aktuelle specifikke behov fra kunderne.

Hertil kommer, at der i øjeblikket er antal forskellige måder at håndtere recyling af plastik. Der er behov for at skabe større grupperinger for styring af side-strømme for at øge volumen og økonomisk realiserbarhed.

Der eksisterer en række forskellig fora, som fx. WEEE Forum og Next Wave og flere andre, som kunne samarbejde og tage ledelsen af rundbordssamtalerne. Producentansvar organisationerne i EU medlemsstaterne kunne også fungere som katalysatorer for forandring; eksempelvis har ESR skabt et økosystem omkring WEEE industrien for at udvikle mere effektive indsamlings og processerings faciliteter i Frankrig.

Materiale identifikation and cirkulære materialevalg

Materiale identifikation er en forudsætning for den størst mulig værdibevarelse. Ukorrekt mærkning på plastik har resulteret i situationer hvor recyclere ikke har tillid til mærkningen hvilket betyder at forskellige typer af plast ikke bliver separeret selvom det teknisk er muligt.

Tæt knyttet til identifikation er muligheden for at harmonisere brugen af plast. Gennemgang af de forskellige typer plast, der anvendes i produktionen og efterfølgende skift til de mest anvendte plasttyper er en effektiv måde at bidrage til recycling. Sådanne lister over mest brugte plasttyper skal imidlertid laves i samarbejde med branchen, da det har direkte betydning for recyclerne. Hvis recyclerne vidste hvilke plasttyper de modtog, ville de kunne lave de nødvendige investeringer i nye teknologier og dermed opnå en mere konsistent materialekvalitet. Desuden vil det øge mulighederne for cirkulering markant hvis tilsats-kemikalier og additiver blev fjernet fra produkterne.

Lovgivning

Myndighedskrav om at anvende recirkulerede materialer kan påvirke skiftet mod cirkularitet positivt. En første tiltag kunne være branche-baserede krav til design principper, som kunne omhandle mulighed for reparation, modularitet, mulighed for opgradering og lethed ved adskillelse. Næste trin kunne så være et bredere regelsæt.

Andre vigtige tiltag er at fjerne eksisterende barrierer, såsom transport af e-affald på tværs af grænser inden for EU. De nordiske lande har gode forudsætninger for at opbygge et Nordisk samarbejde, der kunne harmonisere tilbagetagnings-systemer og dermed være forbillede for en skalering til større systemer.

Indlejring af miljøvurderinger i beslutningsprocessen

For at arbejde inden for planetens grænser for forbrug er det vigtigt at produkter designes, fremstilles og cirkuleres på en måde, der bringer os tættere på cirkulær økonomi. Ved at beregne forhindrede miljømæssige omkostninger opnås en god business case og et godt beslutningsgrundlag for at starte den cirkulære rejse.

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Designing plastics circulation – electrical and electronic products
Presently most electrical/electronic equipment (EEE) is not designed for recycling, let alone for circulation. Plastics in these products account for 20% of material use, and through better design, significant environmental and financial savings could be gained. Technological solutions and circular design opportunities already exist, but they haven't been implemented yet. Some challenges, such as ease of disassembly, could be resolved through better communication and by sharing learnings across the value chain.

Instead of WEEE, we should focus on developing CEEE: Circular Electrical and Electronic Equipment.

The case examples of this report show how different stages of the lifecycle can be designed so that plastics circulation becomes possible and makes business sense. It is time to take a leap in material flow management and scale up these circular solutions across the industry.

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